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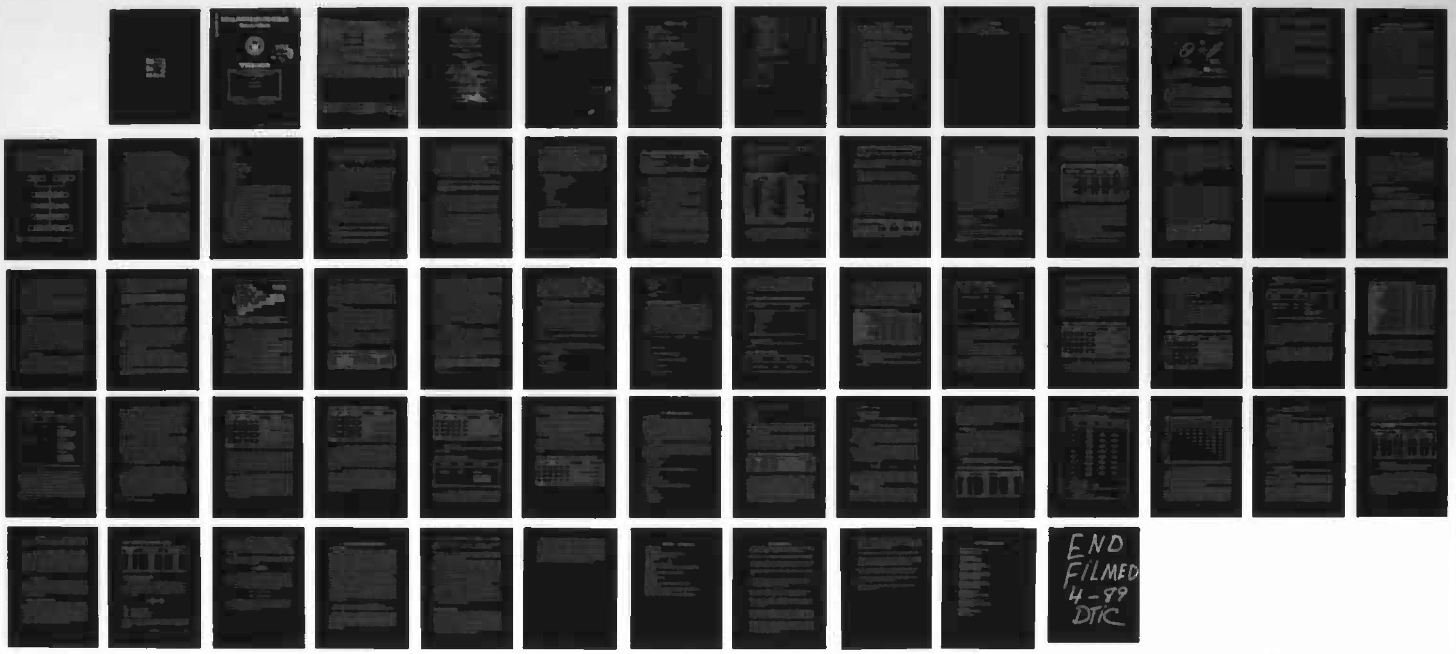

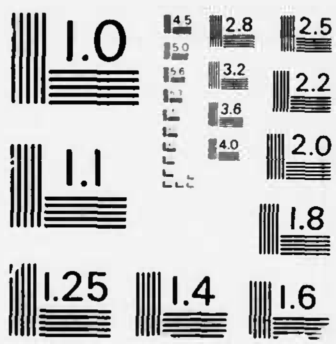
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NAVAL POSTGRADUATE SCHOOL

Monterey, California

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AN "EXCELLENT PILOT MODEL" FOR THE KOREAN AIR FORCE

by

Park, Jin Hwa

December 1988

Thesis Advisor Ronald A. Weitzman

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The Korean Air Force is continuously being challenged with the problem of whether to drop or retain a student who is having difficulties in flight training. The pass or fail decision is critical not only to the Korean Air Force but also to the student pilot himself. The purpose of this study is to determine and standardize criteria of excellence in order to improve the success of the student pilot screening process. The following two research questions are addressed: (1) What are the primary factors that predict aviation excellence ? (2) How do these factors apply to student pilot screening in the Korean Air Force ? The anticipated benefit of this study is the improvement in the screening of undergraduate pilots in the Korean Air Force.

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by

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Major, Korean Air Force
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The Korean Air Force is continuously being challenged with the problem of whether to drop or retain a student who is having difficulties in flight training. The pass or fail decision is critical not only to the Korean Air Force but also to the student pilot himself. The purpose of this study is to determine and standardize criteria of excellence in order to improve the success of the student pilot screening process. The following two research questions are addressed: (1) What are the primary factors that predict aviation excellence ? (2) How do these factors apply to student pilot screening in the Korean Air Force ? The anticipated benefit of this study is the improvement in the screening of undergraduate pilots in the Korean Air Force.

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I. INTRODUCTION

A. BACKGROUND

Selecting high-quality pilots is particularly significant to the Korean Air Force because the Korean Air Force is inferior in size to the Air Force of communist North Korea. In terms of military balance [1], the Korean Air Force is outnumbered in both manpower and equipment by the Air Force of communist North Korea. Despite Korean Air Force efforts to fill the gap, the air power ratio has remained at a constant level. As a result of this imbalance, the Korean Air Force must offset numerical inferiority with technology and high-quality pilots.

As long as the Korean Air Force uses a predictor with a less than perfect validity ($r = 1.00$) for screening student pilots, some errors will occur [Ref. 1 : P. 202]. Making *false selections* (e.g., some pilots who are selected should not be selected) is highly undesirable because of the cost of training [2], reduced efficiency, a decrease in air combat readiness and so forth. In addition, aircraft accidents due to pilot error stress the importance of pilot selection even more.

In the current Korean Air Force pilot selection system, the instructor performs several roles for his students. These roles include the "father image," the counselor, and the teacher. To some degree, he is also a psychologist. He is the first one to say, "My student can fly or cannot fly." Of course, there is a whole process that involves "washing out" a pilot candidate, but the instructor pilot has to make the decision if an individual has flying skills that are worth pursuing or if it's in everybody's best interest for him to do something else for a living.

Usually, instructors make this decision using standards derived from their own values, personality, or previous experience. Also, the relative importance placed on the various criteria tends to vary from one instructor to another. Therefore, such decisions cannot guarantee that a specific student will be successful at any given time. These unstandardized criteria among instructors are the major reason for low predictor validity and false selection in the Korean Air Force.

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1 Defense Foreign Affairs Handbook 1987-1988.

2 The cost of U.S. Air Force undergraduate pilot training is $368,941. This represents the average cost per graduate in a sample training program and reflects initial or entry-level training only [Ref. 2 : p. 66].

To reduce the number of selection mistakes, the Korean Air Force should increase the validity of the predictor. The greater the validity of the predictor, the smaller the chance of false decision-making in undergraduate pilot screening. (Fig. 1) [Ref. 1 : pp. 204-205].

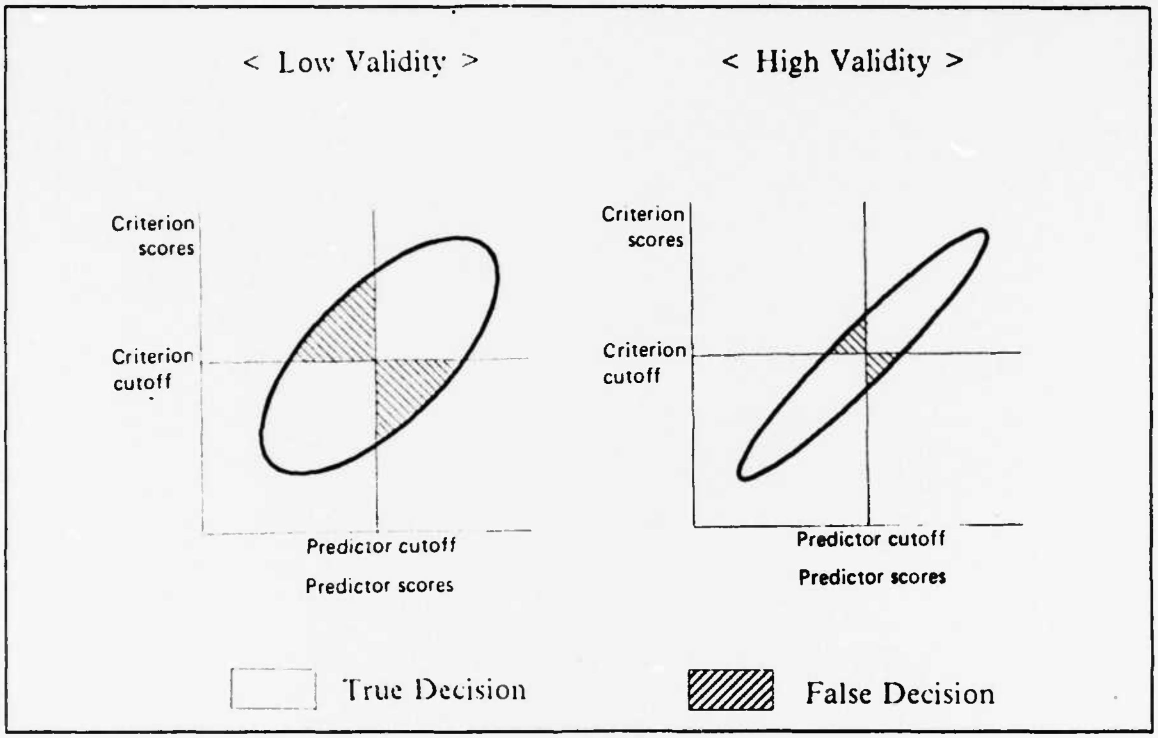

Figure 1. Decision Making in Pilot Selection
Source: Adapted from Muchinsky, Paul M., "Psychology Applied to Work," p. 204, The Dorsey Press, 1987.

B. PURPOSE OF THE STUDY

The purpose of this study is to determine and standardize criteria of excellence in order to improve the success of the student pilot screening process. This study will attempt to identify the qualities that characterize excellence in pilot performance and attempt to relate these qualities to actual flight performance. The questions that will be addressed are:

- What are the primary factors that predict aviation excellence ? and
- How do these factors apply to student pilot screening in the Korean Air Force ?

The Korean Air Force is continuously being challenged with the problem of whether to drop or retain a student who is having difficulties in flight training. The pass or fail decision is critical not only to the Korean Air Force but also to the candidate pilot himself. Thus, the Korean Air Force needs a reliable predictor that can be used to select candidates for flight training program who have a high probability of success.

C. SCOPE

The data used in this study are taken from the "record of training" of the undergraduate pilot training program. This data base contains flight performance grades, academic grades, and quality rating points. A sample of 175 officers was selected from the population of Korean Air Force Academy cadets and ROTC officers. The statistical analysis system (SAS) procedures were used to analyze and process that data set. The intent of this study is to analyze the human characteristics of a general pilot and not focus extensively on a combat-effective pilot.

D. ORGANIZATION OF THE STUDY

The next chapter, "Background and Literature Review," discusses different methodologies, data sets used, and the findings of various studies. Chapter III, "Excellent Pilot Model," develops an empirical model (based on regression analysis) that incorporates factors affecting excellence in aviation in the Korean Air Force. Chapter IV, "Empirical Estimation," presents and discusses the results of this model. Chapter IV also interprets the meaning of the estimated coefficients and discusses the "goodness-of-fit" of the model. The final chapter, "Conclusions and Recommendations," presents the overall findings of the study regarding the relationships between performance in flying and student pilot qualities and makes recommendations for further study of these relationships.

II. BACKGROUND AND LITERATURE REVIEW

A. KOREAN AIR FORCE PILOT SELECTION

The Republic of Korea Air Force (ROKAF) consists of three commands under the Air Force Chief of Staff: the Tactical Air Command, the Education and Training Command, and the Logistics Command. Pilot selection and training are conducted by the Education and Training Command. The Korean Air Force pilot training program consists of three stages. These are the Primary Pilot Training program, the Intermediate Pilot Training program, and the Advanced Pilot Training program.

The Korean Air Force Academy (KAFA) and ROTC are the major sources of pilot candidates for the Air Force. The Primary Pilot Training program is a required course for physically qualified first class (senior year) cadets and ROTC officers who volunteer to attend the pilot training programs. This program is conducted at the Air Force Academy airfield. Air Force pilots and retired pilots are instructors. Instruction includes ground training classes in airmanship, safety, and aircraft system, as well as a flying phase. Pilot candidates must successfully complete this program in order to enter the follow-on Intermediate Pilot Training program.

The Korean Air Force is using an actual in-flight selection system. In this system, all Korean Air Force Academy graduates and ROTC officers who pass the medical examination can enter a Primary Pilot Training program and have a chance to fly. The only admission requirement is a medical clearance. After a certain amount of flying, candidates are evaluated on their flying ability through an initial aptitude checkride. The goal of this checkride is to identify those student pilots who have the basic aptitude to become Air Force pilots. The checkrides of the undergraduate pilot training course are conducted by check instructors who are experienced pilots. They evaluate the student's performance on each maneuver. The evaluator must consider several factors in addition to the student's compliance with maneuver parameters. These factors include demonstrated proficiency, judgment, air sense, and overall ability to safely and confidently maneuver the aircraft.

The Korean Air Force training command uses a multiple "hurdle" selection strategy. In this multiple hurdle system, candidates must get satisfactory scores on a number of flight performance measures. The successful candidate is one who passes each hurdle and gets his wings. First, candidates who meet basic requirements are chosen to comprise a pool of student pilots. To become an Air Force pilot, the initial aptitude checkride is the most important hurdle to the student pilots. At various points, additional hurdles (e.g., solo checkride, final checkride) are presented. Eventually, a certain number pass all the hurdles, and these student pilots become fighter pilots, helicopter pilots, and propeller pilots. To survive in the program, student pilots must pass each hurdle. Figure 2 shows the Korean Air Force Pilot Training Program. [Ref. 1 : p. 217]

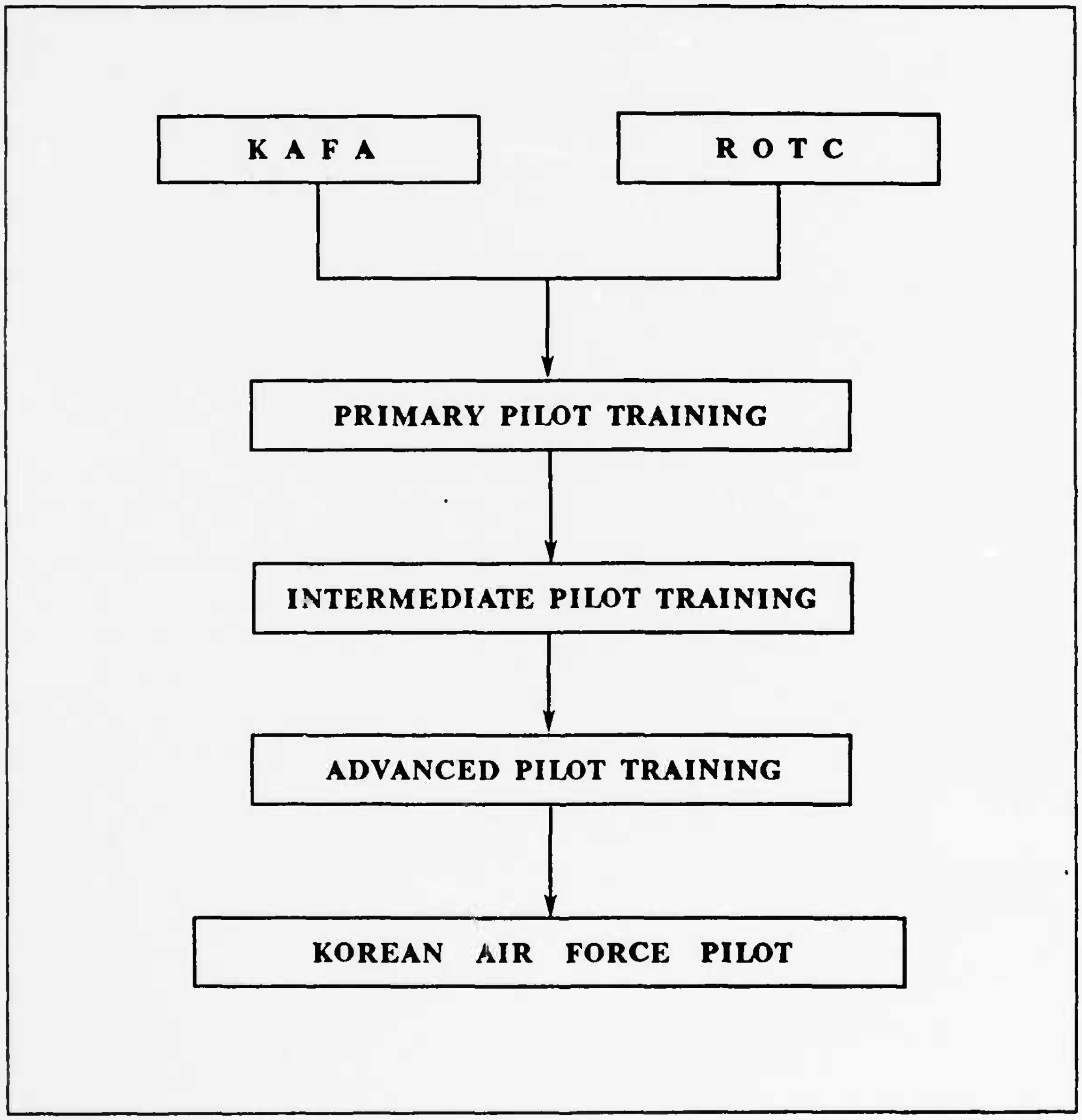

Figure 2. The Korean Air Force Pilot Training Program

B. PREVIOUS STUDIES CONCERNING PILOT SELECTION

From the beginning of aircraft development there have been constant efforts to select individuals who possess both physical and mental attributes conducive to success in flight training [Ref. 3: p. 1]. Pilot candidate selection is the process of choosing a subset of applicants for flight training. Selection implies that some applicants will get accepted while others will not. It is important to understand on what basis applicants are selected for flight training. Selected applicants are predicted to have a higher probability of success than rejected applicants. The basis for this prediction may be a selection test score, the results of an interview, or some other measure. [Ref. 1 : pp. 180-181].

Over time, the pilot selection process has varied considerably. Early wartime selection was determined simply on the basis of medical fitness [Ref. 4 : p. 50]. But it was noted during WW II that a significant number of aircraft accidents were not due primarily to aircraft failures but to human error. Thus, based on these data, several efforts were initiated to predict pilot training success [Ref. 3 : p. 3]. Since the advent of WW II, a large number of studies have been conducted with the goal of identifying factors important in the prediction of success in military pilot training.

The purpose of reviewing previous pilot selection studies is to develop a conceptual framework for the study. This literature review examines the different methodologies and predictor variables employed in various studies and the relevance of previous findings to the present research.

1. Korean Air Force Studies

There are a few studies concerning Korean Air Force pilot selection. One study was performed by Major Lee, a Korean Air Force pilot, in 1986 [Ref. 5]. The purpose of his study was to provide a step toward increasing air combat effectiveness of the Korean Air Force, and further promote the Korean Air Force research activities. By researching previous studies, he found the determinants of a combat-effective pilot: the combat skills and psychological characteristics that have a positive relationship with combat effectiveness. He surveyed 12 Korean Air Force pilots at the Naval Postgraduate School. They had more than 1000 hours of fighter flying time each and more than 5 years in a tactical fighter squaron, which was considered enough experience to make them credible respondents. He asked their opinion of the importance of 12 personal characteristics significant to the combat-effective pilot. These characteristics are:

- Aggressiveness
- Determination
- Desire to achieve
- Initiative
- Courage
- Willingness to take risk
- Psychological stress tolerance
- Physiological stress tolerance
- Anxiety tolerance
- Team coorperativeness
- Endurance
- Leadership

Approximately 85 percent of the pilots rated *desire to achieve, aggressiveness*, and *determination* as being critical or very important personal characteristics. The characteristics *courage, initiative*, and *willingness to take risk* were rated critical or very important by approximately 70-75 percent of the pilots. [Ref. 5 : P. 40]

The results of Major Lee's survey provided valuable information for the future policy of pilot management in the Korean Air Force. For example, the average weighted ratings of the Korean Air Force pilots' psychological characteristics highlight a lack of *aggressiveness* and *willingness to take risk*. He thought that these personality weaknesses might be due to the Korean Air Force basic flying philosophy: "Safety is paramount". Finally, he concluded that the Korean Air Force should focus on analyzing pilot data to select more substantial combat-effective pilots and manage them scientifically for increased air combat readiness. [Ref. 5 : pp. 47-49]

Another study was performed by Captain Park [Ref. 6], who is also a Korean Air Force fighter pilot concerned about the Korean Air Force pilot selection. The purpose of his study was to suggest pilot selection methods that provide potential success in flight training and improve pilot quality. First, he pointed out the problem in the Korean Air Force pilot selection system. The problem is the Korean Air Force cannot adequately take into account a candidate's mental ability due to its poor selection device. He also introduced three aviation selection test batteries currently being used by the U.S. Air Force and U.S. Navy.

Finally, he recommended that the Korean Air Force use psychological tests or test batteries to improve the prediction outcome of the Korean Air Force pilot candidate selection system. He especially emphasized the psychomotor test because some of the psychomotor scores are significantly different between candidates who complete pilot training program and those who do not. [Ref. 6 : p. 50]

2. U.S. Studies

In 1967, James R. Berkshire [Ref. 7] conducted a study to determine whether any of several experimental tests might add significantly to the validity of the test battery that was being used to predict student pilot success in flight training. At that time, the selection test battery included a general intelligence test, the Mechanical Comprehension Test (MCT), and the Spatial Apperception Test (SAT). But it was found that even in the highest selection test group, about 15 percent of the selectees failed to complete the training program. It indicated that an examination of the causes of their failure might reveal areas of flying ability not covered by the selection tests. He used the following experimental tests in his study:

- Altitude Judgment Test,
- Maneuvers Test,
- Instrument Comprehension Test, and
- Background Test[3]. [Ref. 7 : p. 2]

These experimental tests were administered to aviation students during their first week of flight training. Two years later the data were divided into the scores of those who completed and those who did not. He used the Wherry-Doolittle procedure to identify the best combination of variables with which to predict attrition and their appropriate weights. Based on the results of his study, Berkshire offered the following conclusions:

- The instrument Comprehension Test should be validated with the present selection battery.
- The valid items from the Background Test should be incorporated into the Biographical Inventory and revalidated under selection conditions [Ref. 7 : p. 7].

---

3 Twenty item scale used to estimate the cultural (or socioeconomic) level of the respondent's home at the time the aviation student was in high school.

One interesting finding of his study was that the Altitude Judgement Test did not contribute to any prediction formula. Berkshire concluded that it probably intercorrelated with the Mechanical Comprehension Test and the Instrument Comprehension Test [Ref. 7 : pp. 2-3]. Berkshire's study suggests two important predictor variables that can improve predictive validity. The first is instrument comprehension ability, which is one of the flying aptitude variables. Instrument comprehension ability is fundamental to pilots because flying itself requires monitoring many instruments.

The other important predictor variable is biographical information of the pilot candidate. Of all the predictors used to forecast performance, biographical information has consistently shown the greatest validity. Muchinsky [Ref. 1] answered the question "why is biographical information so valid ?" with the following reasons:

- A detailed biographical form samples a large domain of activities and interests in a person's life.
- Biographical information is very reliable. Since validity is limited by reliability, the high reliability of biographical information does not put any *ceiling* on its potential validity [Ref. 1 : p. 157].

There is frequently a fair degree of consistency in people's lives; the individual who played with mechanical toys as a child often retains interest in manipulating mechanical objects as an adult. The psychological axiom that "the best predictor of future behavior is past behavior of a similar kind" is perhaps the core of the validity of biographical information. Accordingly, the instrument comprehension ability factor and biographical factor of a pilot candidate should be included in developing the theoretical *excellent pilot* model.

In 1967, another study of predicting success in flight training was performed by Floyd E. Peterson, Richard F. Booth, Norman E. Lane, and Rasalie K. Ambler [Ref. 8]. Since 1963, the Aviation Psychology Division of the Naval Aerospace Medical Institute has provided information to Naval aviation training administrators confronted with decisions of whether to drop or retain a student who is having difficulties in flight training. Upon request, administrators were given the computed probability of a specific student successfully completing the flight training program. These probabilities were obtained by appropriately weighting valid past performance measures such as initial selection test scores, academic course grades, and flight training grades. They attempted to develop a system for the prediction of student success or failure in Naval Flight Officer Training and thus assist the training administrators in their decisions (e.g., which student in academic difficulty should be given additional instructional time and which should be considered unworthy of additional instruction).

They used the "training record" as basic data for their study. The one strong point of their study is that they excluded the students who dropped for reasons of medical disqualification, personal hardship, and disciplinary action. In order to identify the relationship between academic grades and flight training success, they used the initial selection test scores and the grades received during the flight preparation portion of the academic courses as predictor variables. The breakdown of these tests is as follows:

- Initial Selection Tests
  - Aviation Qualification Test (AQT)
  - Mechanical Comprehension Test (MCT)
  - Spatial Apperception Test (SAT)
  - Biographical Inventory (BI)
- Pre-Flight Tests
  - Aerodynamics
  - Navigation
  - Physiology
  - Physical Training
  - Peer Rating [Ref. 8 : p. 2].

They also used the Wherry-Doolittle method to determine which variables in combination would yield the highest multiple correlation with the criterion. When all variables were used, four variables were selected as significant predictors. Thus, the weights to be applied to the first four variables chosen were computed. By appropriately weighting each of four variables selected, predictor scores were computed for all students included in their analysis sample [Ref. 8 : pp. 1-3]. The variables chosen and the multiple R's are shown in Table 1.

Table 1. VARIABLES SELECTED FOR PREDICTOR SCORE FORMULA

Variables Selected	Cum.Multiple R
Navigation	.360
Mechanical Comprehension Test	.445
Aviation Qualification Test	.458
Power Plants	.463

Source: Peterson, Floyd E. et al., "Prediction Success in Naval Flight Officer Training," p. 3, NAMI-966, February 1967.

An encouraging result of the study by Peterson et al. is the face validity of the four variables chosen. The variable receiving the largest weight is the navigation grade. It is logical that scores received in a navigation course are predictive of future performance in a flight training program which will be heavily loaded with instruction in navigation flight training. This result suggests that pre-flight academic performance has a predictive validity for student pilot success in flight training.

The Korean Air Force does not use any initial selection tests such as the Mechanical Comprehension Test and the Spatial Apperception Test. However, the pre-flight training program includes Aerodynamics, Navigation, Aircraft System and so forth. Therefore, pre-flight academic performance scores would be available for use in an *excellent pilot* model for the Korean Air Force.

Because of the extensive cost of pilot training, there is a constant effort to select individuals who have the greatest probability of successfully completing the pilot training program. Therefore, investigations of the predictive validity of new or untried instruments are frequent. Unlike the other pilot selection tests, which require objective answers, in personality inventories the individual's responses are neither right nor wrong. Test takers answer questions about their personal likes ("I like to go swimming") or how much they agree with certain statements ("People who work hard get ahead"). The basic rationale behind this test is that successful pilots have certain interests or personality patterns [Ref. 1 : p. 142].

Thus, much research has been devoted to investigating paper-and-pencil and projective personality inventories to determine their usefulness in predicting motivational categories of attrition in pilot training programs. In this vein, in 1966, Howard L.

Fleischman, Rosalie K. Amber, and Floyd E. Peterson [Ref. 9] examined the relationship of five personality scales to success in naval aviation training. The five scales are as follows:

- Cattell's Sixteen Personality Factor Questionnaire (Table 2),
- the Taylor Manifest Anxiety Scale,
- the Alternate Manifest Anxiety Scale,
- the Pensacola Z Scale, and
- the Adjective Check-List.

Table 2. SIXTEEN PERSONALITY FACTORS

VARIABLE	High Score	Low Score
Factor A	Warm, Sociable	Aloof, Stiff
Factor B	General Intelligence	Mental Defect
Factor C	Mature, Calm	Immature, Unstable
Factor E	Aggressive, Competitive	Milk-Toast, Mild
Factor F	Enthusiastic	Glum, Sober, Serious
Factor G	Conscientious, Persistent	Casual, Undependable
Factor H	Adventurous	Shy, Timid
Factor I	Sensitive	Tough, Realistic
Factor L	Suspecting, Jealous	Accepting, Adaptable
Factor M	Unconventional	Practical
Factor N	Sophisticated, Polished	Simple, Unpretentious
Factor O	Timid, Insecure	Confident, Self-Secure
Factor Q1	Radicalist	Conservatism of Temperament
Factor Q2	Self-Sufficient	Sociably Group Dependent
Factor Q3	Controlled	Uncontrolled, Lax
Factor Q4	Tense, Excitableous	Phlegmatic, Composed

Source: Fleischman, Haward L. et al., "The Relationship of Five Personality Scales in Naval Aviation Training," p. 1, NAMI, May 1966.

They administered the five personality scales to approximately 700 Navy and Marine aviation cadets in 1964 during their first week of training at the U.S. Naval School, Pre-Flight. In addition to the twenty personality variables included in the five scales, they included the initial selection variables and pre-flight variables in their analysis. These variables are:

- Initial Selection Variables: Biographical Inventory (BI), Aviation Qualification Test (AQT), Mechanical Comprehension Test (MCT), and Spatial Apperception Test (SAT).
- Pre-Flight Variables: Principles of Flight, Navigation, Engines, Physical Training, and Peer Rating.

Intercorrelation matrices consisting of the initial selection variables, pre-flight variables, personality variables, and three dichotomous criteria were computed. In particular, they differentiated three types of flight failure:

- Pass/Fail (composed of successful student aviators and flight failures).
- Pass/Drop (composed of successful student aviators and voluntary withdrawals).
- Pass/Attrite (composed of successful student aviators and attritions for any reason other than medical).

For each of the three criterion groups, the Wherry-Doolittle method of multiple regression was used to determine the extent to which scores on the personality scales contributed to the predictive validity of the prediction system. Prediction formulae were computed both with the personality scales included and excluded, and the significance of increases in multiple correlations were determined by F-tests. [Ref. 9 : p. 3].

The extent to which the inclusion of personality scales increased prediction of the three dichotomous criteria is shown in Table 3. The largest increase in multiple R was for the Pass and Drop criterion. All increases, however, were significant beyond the .01 level. Results indicate that the addition of certain personality measures to the multiple prediction formula increase the predictive validity for the three dichotomous criteria of success and failure. [Ref. 9 : pp. 2-5].

Table 3. MULTIPLE POINT-BISERIAL CORRELATIONS

	Pass/Fail	Pass/Drop	Pass/Attrite
Personality Scales Excluded	0.359	0.150	0.286
Personality Scales Included	0.425	0.270	0.381

Source: Fleischman, Haward L. et al., "The Relationship of Five PersonalityScales to Success in Naval Aviation Training," p. 5, NAMI, May 1966.

The study by Fleischman et al. concluded that certain personality variables contribute significantly to the multiple prediction of dichotomous criteria of success and failure. The correlation of the personality scales with the criteria is low in this study. The correlation between the personality scales and the initial selection tests and pre-flight variables is also relatively low. Thus, when considered in conjunction with these predictors, the criterion variance explained by the personality measures is largely independent of the variance explained by the other predictor variables. In the Korean Air Force training program, certain personality traits that indicate a good pilot are emphasized by instructors. Therefore, personality factors will be included in developing the theoretical *excellent pilot* model for the Korean Air Force.

Another interesting and useful study was performed by Waag, Wayne L., Shannon, Richard H., and Ambler, Rosalie K. [Ref. 10] in 1973. Previous investigations had reported significant relationships between confidential instructor ratings in the early primary phase and later success in Naval flight training. Such ratings were found to increase significantly the validities derived solely from selection test scores. However, such findings do not guarantee that confidential rating would augment the variables that were being used student pilot prediction system. Thus, the purpose of their investigation was to determine if, in fact, the use of instructor ratings would increase significantly the validity of the present student pilot prediction system [Ref. 10 : p. 1].

Surprisingly, they used instructor rating as a predictor variable in their study. Confidential instructor ratings of student pilot performance were obtained for a sample of 1,276 student aviators completing primary flight training between July 1969 and December 1970. Specifically, instructors were asked after the seventh or eighth flight to rate their students on each of four questions concerning:

- The probability of the student obtaining his wings,
- The student's motivation,
- The student's headwork[4], and
- The student's reaction to stress. [Ref. 10 : p. 2]

Table 4 presents the results of analysis for the Aviation Officer Candidates (AOC) sample. As indicated, 5.7 percent of the criterion variance could be explained

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[4] Headwork is the ability to understand and grasp the meaning of instructions, demonstrations, and explanations.

by information available prior to primary flight training. The addition of the instructor rating on item 1 (the probability of the student obtaining his wings) increased the explained variance by 4.6 percentage points, a fairly substantial amount. Finally, upon entering the Pre-Solo grade, an additional 3.3 percent of the criterion variance was explained. The final equation yielded a multiple R of .369. [Ref. 10: p. 6]

Table 4. SUMMARY OF REGRESSION ANALYSIS FOR AOC SAMPLE

Variables Entered	Multiple R	Multiple R-square	Increase In R-square	F-Ratio For Inclusion
Engineering	0.165	0.027	0.027	12.834
Officer-Like Qualities	0.204	0.041	0.014	6.869
Physics Exemption	0.223	0.050	0.009	3.853
Aerodynamics	0.233	0.055	0.005	2.314
Mechanical Comprehension Test	0.238	0.057	0.002	1.128
Item 1-Wings	0.321	0.103	0.046	23.230
Pre-Solo Grade	0.369	0.136	0.033	17.450

Source: Waag, Wayne L. et al., "The Use of Confidential Instructor Rating for the Prediction of Success in Undergraduate Pilot Training," p. 6, NAMI, February 1967.

The results of this investigation clearly indicate that confidential ratings obtained from primary flight instructors can provide valuable information related to a student's likelihood of receiving his wings. More importantly, such ratings significantly increased the predictive validities derived from information that was being used in the Student Pilot Prediction System. This suggests that the instructor's confidential evaluation may provide additional information beyond that reflected in the grades he assigned [Ref. 10 : p. 7]. Waag et al. gave the following reasons to support their recommendation that such ratings be considered for implementation:

- The results do replicate the previous finding that:
  - instructor ratings are significantly related to success in naval air training, and
  - instructor ratings significantly increase the predictive validities derived solely from the selection test scores.
- The results are based upon a relatively large sample size [Ref. 10: p. 8].

The flight instructor serves a dual function. Although his principal duty is to teach students to fly, he must also evaluate their progress for the record. In the Korean Air Force pilot training program, a particular student is assigned to a single instructor. Consequently, the instructor is able to observe the student's initial reactions to flight as well as the progress he makes. An instructor evaluates the student's characteristic performance on each maneuver attempted during each dual sorties or observed during a solo mission. Each student pilot's flight performance is converted into a quantitative score expressed as a percentage. In each maneuver area, a certain number of points is awarded for grades in the following categories:

U	Unable to Accomplish
F	Fair
G	Good
E	Excellent

The point values for each grade vary based on the relative weight of the maneuver area. The overall percentage is computed by adding up all the maneuver area point values awarded and dividing the sum by the maximum possible points. However, it is possible that an instructor's actual opinion regarding a student's progress may not be completely reflected in the grades he assigns. Consequently, the utilization of a confidential instructor opinion may add significantly to the information available from assigned grades. In other words, the flight instructor's perspective should be an excellent vantage point for evaluating the potential success of his student. [Ref. 11 : pp. 5-7]

In 1977, a study performed by Robert A. North and Glenn R. Griffin provided a wide-range description of tri-service aviator selection testing methods and assessed their predictive improvement. In addition, the study suggested methods to improve the prediction of aviator success based upon results and findings in their research literature. [Ref. 3 : p. 1] They summarized their findings as follows:

> The potential for increased success in predicting aviator performance is high. The fact that current selection tests normally account for less than half of the total variance associated with aviator success (in training) suggests that there are additional factors associated with aviator performance which are not now being adequately assessed. The lack of any prominent breakthrough in perceptual and cognitive paper-and-pencil testing since war years (WW-II) suggests that non-paper-and-pencil performance tests should be investigated more fully to determine their relationship to aviator performance in both a training and operational setting [Ref. 3 : p. 1].

C. SUMMARY

In chapter I, it was pointed out that the Korean Air Force has low predictor validity in pilot selection derived from unstandardized criteria. Student pilots' psychological factors are measured by instructors based on subjective evaluation. This unstandardized approach results in false selections and false rejections in pilot screening. Thus, the measuring of psychological factors is a major issue of the Korean Air Force pilot training command. In essence, the Korean Air Force must find a more effective way to evaluate a student's psychological factors.

In this chapter, the Korean Air Force and U.S. pilot selection studies were discussed. These studies suggest the methodologies and predictors available to create an *excellent pilot* model for the Korean Air Force. The suggested predictors are flying aptitude factors, biographical factors, personality factors, and the motivation of the pilot candidate. The study of confidential instructor ratings performed by Waag et al. suggests that the implementation of instructor ratings may significantly enhance the validity of the prediction system for the Korean Air Force. The following chapter analyzes Korean Air Force student pilot qualities and specifies the *excellent pilot* model, which may work to improve predictor validity and minimize *false selections* in the Korean Air Force.

III. EXCELLENT PILOT MODEL

This chapter specifies the *excellent pilot* model incorporating factors that affect aviation excellence in the Korean Air Force. The first part of this chapter describes the theoretical basis for the *excellent pilot* model. The criterion and possible predictors for an *excellent pilot* are also discussed in this part. In the next part of the chapter, the empirical *excellent pilot* model (based on the theoretical model) is specified. The method used is multiple regression analysis. The "training record" of the sample students is used as a data base in this model. The "training record" includes a lot of information important for the prediction of pilot training success. The data values are formatted so the computer can read them and the statistical analysis system (SAS) procedures are used to analyze and process that data set.

A. MODEL THEORETICAL SPECIFICATION

1. Excellent Pilot Criteria

Establishing the *excellent pilot* criteria is the first step in evaluating student pilots. Each time we evaluate someone or something, we use criteria.

> Criteria (the plural of criterion) are best defined as evaluation standards; they are used as reference points in making judgments. We may not be consciously aware of the criteria that affect our judgments, but they do exist. We use different criteria to evaluate different kinds of objects or people; that is, we use different standards to determine what makes a good (bad) movie, dinner, ball game, friend, spouse, or teacher [Ref. 1 : p. 99].

In the pilot selection process, criteria are most important for defining the "goodness" of a candidate pilot. What should the criteria be like? According to Muchinsky, criteria must be appropriate, stable, and practical. They should be relevant and representative of the job. They must endure over time or across situations. Finally, they should not be too expensive or hard to measure. [Ref. 1 : p. 77]

Usually, criteria are classified into two categories on the basis of whether they are objective or subjective measures. Objective criteria are taken from flight performance scores, awards, flying times and so on and supposedly do not involve any type of subjective evaluation. Subjective criteria, on the other hand, are taken from a subjective evaluation of a person's performance. The judgment is usually a rating or ranking. [Ref. 1 : pp. 99-106]

Normally, the pilot training class rank order is used as an aggregate criterion of an *excellent pilot* in the Korean Air Force. The class rank order, however, does not completely represent the level of aviation excellence because the instructors rank student pilots from high to low on a given performance dimension. The pilot ranked first is regarded as the "best" and the pilot ranked last as the "worst." However, because rank order data have only ordinal scale property, we do not know how good the "best" is or how bad the "worst" is. [Ref. 1 : p. 314]

Although analysis of excellent pilot criteria has in the past been limited to specific environments and flying communities, this study will propose a general basis for assessment or identification of the individual characteristics and critical skills that are thought to characterize an *excellent pilot*. The total flight performance score will be used as an *excellent pilot* criterion. This total flight performance score is one of the objective criteria and reflects a student pilot's flying skill and psychological factors.

2. Predictors for an Excellent Pilot

A predictor is any variable used to forecast a criterion. In weather prediction, barometric pressure can be used to forecast rainfall. In medical prediction, body temperature may be used to predict illness. In pilot selection, we seek predictor of flight training success criterion indexed by flight performance. The predictor variables related to *excellent pilot* criteria are likely to be performance measures on tests of various kinds (e.g., flying aptitude, personality, decision making, reaction to stress, motor skills). If a correlation exists between these predictors and *excellent pilot* criteria, it will be possible to identify the best potential *excellent pilot* through assessing the relevant factors. However, it is not easy in reality to assess all relevant predictors because of only partial relations of factors to criteria. This section will review traditionally-used predictors, examine their success, and discuss their application potential in creating the *excellent pilot* model.

a. Aptitude Factors

Aptitudes have been successfully used as objective measures to predict flight training success. For example, during World War II, the U.S. Army Air Force Psychology Program was established to develop a full-scale program for selecting aircrew personnel. Under this program, two testing instruments, largely consisting of aptitude material, were developed. One of these was the Army Air Force Qualifying Examination (AAFQE) which was used as a preliminary screening device. This exam included tests for comprehension and judgment, mathematical ability, mechanical comprehension, and observational judgment. [Ref. 12 : p. 3-48] Consequently, a large portion of candidates who would have failed in training or would have required extra training were undoubtedly identified before acceptance into training programs, resulting in the savings of considerable materiel and instructor time. [Ref. 3 : pp.10] The success of the Army Air Force testing program is summarized as follows:

> For every 100 graduates from advanced pilot training desired in the summer of 1943, it was necessary to start 397 men in pilot preflight school. When the men were selected by both the Army Air Force Qualifying Examination and Aircrew Classification Battery (using a stanine score of 7) only 155 men were required to obtain 100 graduates. [Ref. 3: p. 10]

In addition to the Army Air Force's effort, several other tests with aptitude components have been developed. Fairly high correlations have been reported for the Flight Aptitude Rating (FAR) which is based upon scores for mechanical and spatial abilities. [Ref. 12 : p. 3-48] Scores from the FAR test are expressed in stanine scores[5]. In an unrestricted sample these scores usually have a correlation of .40 to .50 (biserial) with a criterion based on whether a student pilot completed or dropped from the program. Figure 3 shows the relationship of the FAR scores to success in flight training. [Ref. 7 : p. 1]

Undoubtedly, the success of FAR ratings and of the Army Air Force testing program strongly support aptitude testing for selecting pilots. Because of the broad-based scientific support for aptitude testing, it seems imperative that it be included in developing the theoretical *excellent pilot* model. However, such aptitude testing does not exist in the Korean Air Force. The flying aptitude of the pilot candidate can only be measured by the flight instructor. Therefore, the instructors' aptitude rating is recommended for use as an aptitude variable instead of aptitude testing.

b. Biographical Factors

"The best predictor of future behavior is past behavior of a similar kind."

For the pilot selection purpose, several instruments have been devised to secure biographical information to predict success in training. Many test batteries also contain biographical components. Biographical factors tend to be of three basic types: life inventory, academic history, and military history. Sometimes, life inventory factors are confused with pilot personality factors. The characteristic tested at the actual time

[5] Stanines are normalized scores with a mean of five, a standard deviation of approximately two and a range of 1 to 9. The word stanine became associated with aircraft specialty tests, but has subsequently been used generally.

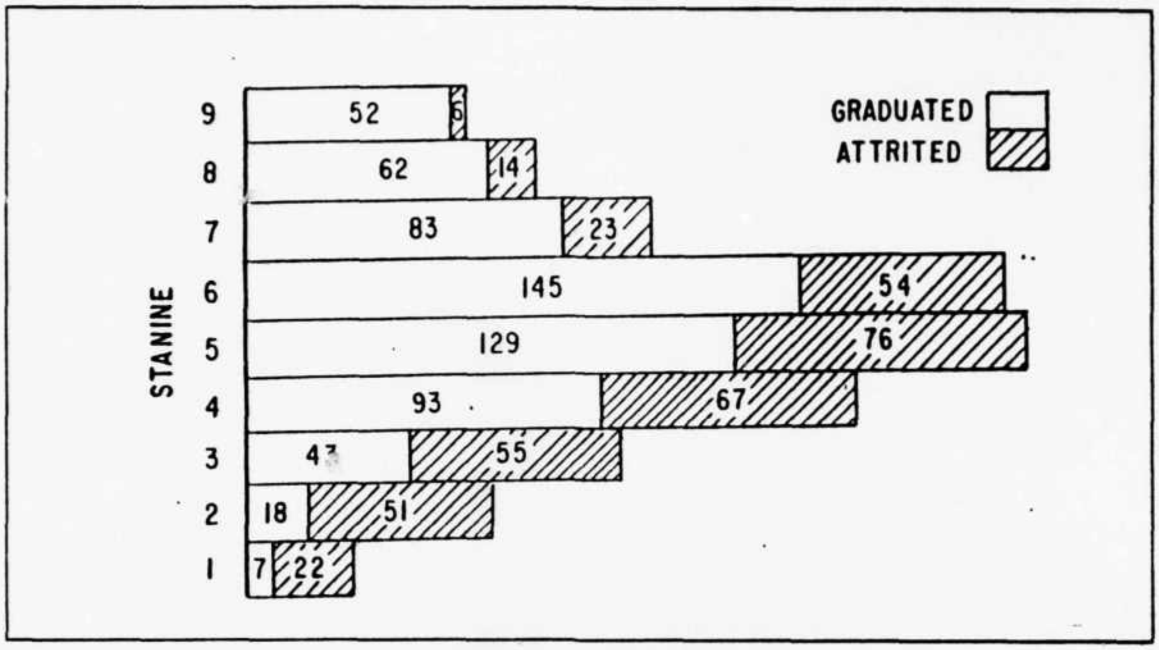

Figure 3. Relationship of FAR Scores to Success in Flight Training

Source: Bershire, James R., "Evaluation of Experimental Aviation Selection Tests," p. 1, NAMI, March 1967.

of pilot selection would be categorized as a personality factor; but earlier or historical manifestations of that characteristic noted at the time of selection would be treated as biographical factors. Because of this possible confusion, the life inventory will not be treated as a biographical factor in this theoretical model specification.

Academic grades constitute one biographical variable that has been found valuable for predicting success in training. Several studies have found significant relationships between pre-flight grades and training criteria. For example, as mentioned in the literature review, Peterson et al. [Ref. 9] reported statistically significant correlations between pre-flight academic performance and pass-fail criterion.

A second important predictor in biographical information is the procurement source, which also appears to be a valuable predictor of success in training. For example, Waag et al. [Ref. 10] studied the relationship between two procurement sources and two criteria: (1) pass-fail, and (2) pre-solo training grades. The two procurement sources were Aviation Officer Candidates (civilians) and Officer under Instruction (commissioned officers). Significant differences were obtained with both criteria, with greater failures and lower training grades for the officer group. [Ref. 10 : p. 5]

In summary, biographical information appears to show promise in predicting pilot training success. Variables showing relationships with training criteria are academic grades and the procurement source. In the Korean Air Force, many academic courses are taught in the pre-flight training program. The Korean Air Force has two different sources of pilot candidates: the Air Force Academy and ROTC. If such biographical information (academic grades and procument sources) were included as the predictors for the *excellent pilot* model, they would improve the prediction of pilot training success.

c. Personality Factors

The assessment of personality factors using paper-and-pencil tests has a long history. Many personality test devices are used in pilot selection programs. In particular, the Minnesota Multiphasic Personality Inventory (MMPI), the California Psychological Inventory (CPI), and Cattell's Sixteen Personality Factors are useful for selecting pilots. [Ref. 12 : pp. 7-9] As mentioned in chapter II, Fleischman et al., examined the relationship of personality scales to success in aviation training and proved that certain personality variables contribute significantly to the multiple prediction of the criteria of success and failure.

The importance of pilot personality can be understood by examining the Israeli Air Force (IAF) pilot selection policy. The candidate's personality plays a significant role in their pilot selection and evaluation. This emphasis is borne out by the composition of the initial rating base for the selection of pilot candidates. Table 5 gives the initial evaluation rating base.

Table 5. ISRAELI AIR FORCE (IAF) INITIAL EVALUATION RATING BASE

ITEMS	PERCENTAGE
Candidate's personality	40
Perceptual/Motor test	30
Background variable	30

Source: Younggling, W. E. et al., "Feasibility Study to Predict Combat Effectiveness for Selection Military Roles," p. 81, McDonnell Douglas, April 1977.

Following this initial evaluation, recruits are sent to a 10-day selection and screening camp with a new group of behavioral scientists and instructor pilots to assess the candidates' motivation, ability to innovate, aggressive traits, leadership, and other traits as observed through their activities. The IAF takes every necessary step in assuring that the best people are selected. In essence, the IAF believes that a pilot's personality may be more important than his individual flying skills. [Ref. 12 : p. 3-81]

Some personality factors seem to show promise for predicting success in pilot training. However, there is a weakness in personality testing. The problem with utilizing such personality devices and projective tests is their reliance on the individuals to provide honest and objective self evaluations, even though such evaluation has the potential to prohibit the individual's entry or continuation in aviator training. This can lead to the phenomenon of "faking the test" or test response bias. This can occur as a direct result of the subject's ability to select the best item response that is most socially acceptable [Ref. 3 : p. 18]. Therefore, a student's personality evaluation by a flight instructor will be more reliable rather than self-evaluation personality test scores. Therefore, the use of the instructors' personality rating would increase predictability in the *excellent pilot* model.

d. Motivation Factors

One of the fundamental requirements for success in flight training is a positive attitude towards flying, especially if the student aims to make it his profession. This attitude should stem from a sound motivation which in turn should stem from a proper awareness of the profession's requirements. [Ref. 13 : p. 33]

One of the major theories of motivation was developed by psychologist Abraham Maslow. It is called the *need hierarchy theory*. According to Maslow, the source of motivation is certain needs. He proposed five stages of needs: physiological, safety, social, self-esteem, and self-actualization. Maslow's *need hierarchy theory* was employed by Bucy and Burd [6] to prove the relationship between motivation and aviation training success. The principle findings were as follows:

> Successful candidates were significantly more optimistic with respect to all needs with the exception of physiological needs. Largest differences appeared with the need for self-actualization. Therefore, it appears that expectations with regard to need satisfaction might be a valuable predictor of voluntary withdrawal elimination. [Ref. 12 : p. 3-55]

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6 Cited by Younggling et al., [Ref. 12 : p. 3-55]

It is evident that a highly motivated student pilot's performance is better than that of a poorly motivated one. The rationale is that "a performance is the product of motivation and ability moderated by situational constraints." Ability is the student's capability for performing certain tasks. Ability is necessary but insufficient to ensure a best performance. Usually, people perform best when they have the desire to perform a task well and also when they possess sufficient ability. Motivation, therefore, would be an important factor in predicting student pilot success in training.

3. Theoretical Excellent Pilot Model

The *excellent pilot* should have good flying aptitude, desirable personality traits, sufficient knowledge, and high motivation for his job. The greatest likelihood of producing an *excellent pilot* is through selection based on all of these relevant factors. However, in reality, it is impossible to apply all relevant factors (assessed or not assessed) to pilot selection and the evaluation. It is, therefore, more appropriate to consider some critical predictors for selection rather than to consider all relevant factors.

In the "model theoretical specification" above, a variety of predictors are discussed that have proven to be related to criteria of success in pilot training. These predictors fall into four distinct domains: flying aptitude, biography, personality, and motivation. The formula for the *excellent pilot* model with these predictors will be:

Excellent Pilot = f (flying aptitude factors + biographical factors + personality factors + motivational factors)

Based on the discussion above and the author's previous experience as an instructor pilot, the following variables from the "record of training" seem most likely to apply in the theoretical *excellent pilot* model:

(1) Flying Aptitude Factors

- Inherent flying aptitude.
- Dividing of attention.

(2) Biographical factors

- Flight performance grade,
- Academic performance grade,
- Commission source.

(3) *Personality Factors*

- Calmness,
- Self-confidence,
- Flexibility.

(4) *Motivational Factor*

- Motivation.

B. MODEL EMPIRICAL SPECIFICATION

To empirically estimate the effect of human quality on flight performance, this part analyzes qualities of Korean Air Force student pilots. Multiple regression analysis is used to systematically compare the correlation between flight performance and each predictor variable. While a correlation coefficient is useful for showing the degree of relationship between two variables, it is not useful for predicting one variable from the other. Regression analysis, however, does permit prediction of a student pilot's status on one variable (the flight performance score) based on his status on another variable (predictor variable) [Ref. 1 : p. 181]. The multiple regression model assumes that the dependent variable Y is a linear function of a series of independent variables $X_1, X_2, \ldots\ldots\ldots, X_k$ and an error term. We write the multiple regression as

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots\ldots\ldots\ldots + \beta_k X_{ki} + \varepsilon_i \qquad (i = 1, 2, \ldots\ldots n) \qquad (3.1)$$

where:

Y = the dependent variable

X_i = the explanatory or independent variable

ε_i = the error term associated with the i th observation

β_i = the regression coefficients

n = the number of the observation

In the "model theoretical specification", eight independent variables are presented. The presence of highly intercorrelated independent variables may add little to the predictive power of the model. However, these variables will be maintained in the final model even if their explanatory power is low because they are considered very important. Table 6 gives the independent variable names and their expected relation to flight performance.

Table 6. INDEPENDENT VARIABLES AND EXPECTED RELATION

VARIABLE	EXPECTED SIGN
Inherent Flying Aptitude	+
Dividing of Attention	+
Academic Performance	+
Commission Source	-
Calmness	+
Self-confidence	+
Flexibility	+
Motivation	+

1. The Dependent Variable

Table 7 shows the dependent variable's code name and the value coding in the SAS program.

Table 7. DEPENDENT VARIABLE

VARIABLE	CODE	VALUE CODING
Flight Performance	FLY	Continuous

The total *flight performance* score is used as a dependent variable in the multiple regression model. Table 8 gives the flight performance weighting base currently used in the Korean Air Force Air Training Command. The *flight performance* score consists of the sum of several checkride grades (70 percent) and each flight grade (30 percent). The flight instructor evaluates a student's flight performance and grades his performance according to the grading policy. The checkride is not conducted by the instructor responsible for teaching a pilot, but by an impartial "check" instructor. As indicated in Table 8, the maximum possible total score is 650. The flight performance of sample students ranged from 439 to 574, with a mean value of 514.6.

Table 8. FLIGHT PERFORMANCE WEIGHTING

CHECKRIDE	*WEIGHT*	*CHECK NON-CHECK*
Initial Aptitude Check	*50*	*35 15*
Solo Possibility Check	*40*	*28 12*
Landing (solo)	*20*	*20 0*
Intermediate Air Work Check	*100*	*70 30*
Final Air Work Check	*140*	*98 42*
Instrument Flight	*100*	*70 30*
Formation Flight	*130*	*91 39*
Navigation Flight	*40*	*28 12*
Instrument Flight Simulator	*30*	*30 0*
TOTAL	*650*	*470 180*

Source: "Third-Training Wing Manual 60-37: Evaluation of the Student Pilot," p. 3, Seoul, 1980.

2. The Independent Variables

This section defines independent variables and discusses the hypothesized relationship between flight performance and predictor variables.

a. Flying Aptitude Variables

Table 9 shows the flying aptitude variables' code name and the value coding in the SAS program.

Table 9. FLYING APTITUDE VARIABLES

VARIABLE	CODE	VALUE CODING
Inherent Flying Aptitude	APT	Continuous 1 = D (poor aptitude) 2 = C (fair aptitude) 3 = B (good aptitude) 4 = A (excellent aptitude)
Dividing of Attention	ATT	Continuous 1 = D (poor division) 2 = C (fair division) 3 = B (good division) 4 = A (excellent division)

(1) *Inherent Flying Aptitude.* Flying requires a certain sense to process information. The Korean Air Force pilots call this *inherent flying aptitude* (i.e.,the ability to grasp numerous perceptions simultaneously and to convert them into immediate and precise reactions). The *inherent flying aptitude* can be explained by examining the following inborn elements:

- multilimb coordination--performance of simultaneous tasks with hands or feet.
- spatial orientation--judgment of position in three dimensional space.
- response orientation--rapid response to changing stimulus conditions, and
- rate of control--responses in anticipation of velocity of rate change. [Ref. 3 : p. 20]

Inherent flying aptitude can only be judged objectively by a pilot's behavior, actions, and responses, and not by his perceptions and knowledge. Generally, there is a sequence in flight training. The sequence is the "imitation of maneuver stage", the "intellectual control over the aircraft stage", and finally the "automatic control stage". *Inherent flying aptitude* is usually judged by the instructor in the first stage of training (when new exercises are being practiced). In this stage, a spatial sense, directional sense, and multilimb coordination are required by the student to imitate his instructor.

Most instructors agree that *inherent flying aptitude* is a fundamental and critical factor for a pilot. Therefore, this *inherent flying aptitude* should be used as a predictor variable in the selection process. It is hypothesized that the correlation between the *flight performance* and a pilot's *inherent flying aptitude* will be highly positive and significant.

Table 10 gives the *inherent flying aptitude* grade distribution and grading criteria. The instructors evaluated their students' *inherent flying aptitude* throughout the flight training program. According to the grading criteria, the *inherent flying aptitude* variable was measured by how completely a student met the requirement of a maneuver after the instructor's demonstration. Only 26.9 percent of the students performed the maneuver quite well with minimal advice from the instructor. On the lower end of the grade scale, 10.3 percent of the students failed to perform the maneuver despite several demonstrations by the instructor.

Table 10. FLYING APTITUDE GRADING CRITERIA AND DISTRIBUTION

GRADE	FRE-QUENCY	PERCENT	CRITERIA
A	*47*	*26.9*	*A student completely meets the requirement of a maneuver without any deviation after the instructor's demonstration.*
B	*56*	*30.9*	*A student meets the requirement of a particular maneuver with minor deviation.*
C	*54*	*30.9*	*A student meets the requirement of a particular maneuver with a lot of advice and corrections by the instructor.*
D	*18*	*10.3*	*A student failed to meet the requirement despite several demonstrations and corrections by the instructor.*
TOTAL	*175*	*100*	

(2) Dividing of Attention. The technology of today's high performance aircraft demands a pilot's rapid and accurate instrument comprehension ability. For example, to properly control an aircraft in the instrument flight, the pilot should be able to read at least four instruments simultaneously. These instruments provide attitude,

altitude, air speed, and heading information. In addition, this information is dynamic both qualitatively and quantitatively. It changes constantly and the rate of change may not be standard between the different instruments' information. Therefore, a pilot should be able to mentally process the total information made up of continually changing specific bits of information. *Dividing of attention* involves several abilities:

- ability to judge perceptions quickly and accurately,
- ability to distribute and shift attention,
- alertness of response, and
- good simulation ability and memory. [Ref. 12 : p. 3-66]

In flight training, *dividing of attention* is considered one of the most essential factors in pilots. Table 11 gives the *dividing of attention* grade distribution and grading criteria. The *dividing of attention* variable was measured by a student's cross-check ability and his information processing ability. Only 21.1 percent of the students divided their attention properly and processed total information. On the lower end of the grade scale, 31.4 percent of students overconcentrated their attention on a single instrument. Consequently, these students caused flight errors because they lacked information processing ability.

Table 11. DIVIDING OF ATTENTION GRADING CRITERIA AND DISTRIBUTION

GRADE	FRE-QUENCY	PERCENT	CRITERIA
A	*37*	*21.1*	*A student divides his attention properly and processes total information without fixing his attention on a single instrument.*
B	*35*	*20.0*	*A student does not fix his attention on a single instrument but does take some time to process the total information.*
C	*48*	*27.4*	*A student needs advice to prevent fixing his attention on a single instrument.*
D	*55*	*31.4*	*A student overconcentrates his attention on a single instrument and does not process the total information despite a lot of advice.*
TOTAL	*175*	*100*	

b. Biographical Variables

Table 12 shows the biographical variables' code names and the value coding in the SAS program.

Table 12. BIOGRAPHICAL VARIABLES

VARIABLE	CODE	VALUE CODING
Academic Performance	ACA	Continuous
Commission Source	SOU	Dummy 0 = Air Force Academy cadets 1 = ROTC officers

(1) Academic Performance. Table 13 gives the academic courses and their weighting base. An *academic performance* is determined by the total of pre-flight examination scores, which is used as a continuous variable in the regression model of this study. The maximum possible score is 400. The *academic performance* of the sample students ranged from 337 to 383 and the mean value was 374. Some studies have already proved positive relationships between pre-flight academic grades and training criteria. Thus, this *academic performance* variable is expected to have a positive relationship with the dependent variable.

(2) Commission Source. The *commission source* is not a continuous variable but a dummy variable. The sample is divided into two subsets: one is the KAFA cadet group, and the other is the ROTC officer group. The cadet group is coded as 0, and the ROTC officer group is coded as 1 for the regression analysis. The *flight performance* of the cadet group is expected to be higher than that of the ROTC officer group.

Table 13. ACADEMIC COURSES AND WEIGHTING

ACADEMIC COURSE	*HOURS*	*WEIGHT*
Aeronautics	*25:00*	*40*
Aircraft Maintenance	*20:00*	*25*
Instrument Flight	*25:00*	*30*
Local Procedure	*2:00*	*10*
Transition	*10:00*	*20*
Pre-flight Test	*2:00*	*50*
Meteorology	*10:00*	*10*
Aviation English	*20:00*	*20*
Regulation & Periodical	*15:00*	*25*
Principles of Aviation	*10:00*	*20*
Navigation	*10:00*	*20*
Formation Flight	*4:00*	*20*
Night Flight	*2:00*	*10*
Flying Safety	*3:00*	*10*
Integral Test	*2:00*	*50*
Athletic	*60:00*	*30*
TOTAL	*220:00*	*400*

Source: "Third-Training Wing Manual 60-37: Evaluation of the Student Pilot," p. 10. Seoul. 1980.

The rationale for the difference between these two groups is that KAFA cadets are self-screened individuals who have already shown their motivation to become pilots. The sample size of the ROTC officer group is relatively smaller than the KAFA cadets group. Therefore, the *commission source* variable may be insignificant due to the small relative size of the ROTC officer group.

c. *Personality Variables*

The list of personality variables is presented in Table 14. All variables are continuous. Each student was observed during flight training and his personality was rated by the instructor.

Table 14. PERSONALITY VARIABLES

VARIABLE	CODE	VALUE CODING
Calmness	CAL	Continuous 1 = D (mix-up) 2 = C (visibly shakened) 3 = B (slightly shakened) 4 = A (remain calm)
Self-Confidence	CON	Continuous 1 = D (no confidence) 2 = C (low confidence) 3 = B (some confidence) 4 = A (full confidence)
Flexibility	FLE	Continuous 1 = D (no flexibility) 2 = C (low flexibility) 3 = B (some flexibility) 4 = A (great flexibility)

(1) *Calmness.* *Calmness* is considered a very important pilot characteristic because pilots often encounter unexpected bad flying conditions. The *calmness* trait required by a pilot is the ability to stabilize and to control his emotion despite unexpected disturbances. If the student's mood is generally shakened and his attention is stressed additionally by multiple tasks, a small aberration alone could result in considerable pilot confusion. This confusion leads to the blocking of normal receptivity to information when reading or interpreting instruments or listening to radio communications. When this happens, the student overconcentrates on a single instrument instead of making a proper cross-check. Consequently, his entire perceptual organization breaks down. [Ref. 13 : pp. 34-35]

Physical symptoms of being "shaken" can be observed in the student when he is manipulating the controls. Not only does intellectual efficiency deteriorate, but "shakiness" also hampers a pilot's physical movements. Symptoms range from "freezing on the controls" to the complete disorder of sensorymotor skill. "Freezing" is evident in all forms of control handling; hand-control movements, tensing of muscles, loss of feel for controls, bad or false trimming and overcorrections during maneuvers. For example, a worst case example of being "shakened" in flying is a confusion of control movements to the extent that a student pilot cannot control the aircraft during visual or instrument flight. A student pilot is particularly susceptible to this experience during recoveries from unusual attitudes[7]. Extreme sensory disorder is reached when a student no longer knows what he is doing. [Ref. 13 : pp. 35-36]

Table 15 gives the *calmness* grading criteria and grade distribution. According to the grading criteria, the *calmness* variable was measured how well a student coped with unexpected situations. The *calmness* variable is expected to have a positive relationship with *flight performance.* Only 37.7 percent of students were remained calm despite an unexpected change of situations. On the lower end of the grade scale, 13.7 percent of the students were very much shakened by an unexpected change of situations and could not perform the follow-on procedure. The *calmness* of a pilot might be related to flying safety. Sometimes aircraft accidents occur due to pilot error. A confused pilot may not follow emergency procedures properly, for instance. Usually, a student's *calmness* can be identified during his first solo flight.

(2) Self-confidence. *Self-confidence* is defined as "a belief in one's own abilities." Any student who performed the maneuver or procedure without hesitation can be described as having *self-confidence.* Anxiety about flying and the associated fear of having an accident play an insignificant role because, as a rule, students have embarked on flight training voluntarily. However, throughout training the student displays numerous feelings of anxiety for other reasons and these may severely handicap the display of his capacity or even ruin it. Among the reasons for pilot anxiety is the fear of poor grades, the fear that inadequate ability may negatively affect his future career, or the fear, due to various reasons, of his instructor. In addition, hidden and subconscious fears, often lead to a lack of efficiency, the deeper causes of which are not always immediately evident. [Ref. 13: pp. 35-36]

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[7] Anything other than straight and level flight

Table 15. CALMNESS GRADING CRITERIA AND DISTRIBUTION

GRADE	FRE-QUENCY	PERCENT	CRITERIA
A	66	37.7	*A student remains calm despite an unexpected change of situations.*
B	41	23.4	*A student is slightly shakend by an unexpected change of situations but immediately stabilizes and performs the procedure.*
C	44	25.1	*A student is visibly shakened by an unexpected change of situations and needs advice to perform the procedure.*
D	24	13.7	*A student is very much shakened by an unexpected change of situations and cannot perform the procedure.*
TOTAL	175	100	

In addition to this, flight errors are increased by insufficient confidence in his own ability, in the flight instructor or his way of teaching, or in the aircraft. Low self-confidence is most evident in cases where the student's attitude is characterized by suspicion of the instructor, distrust of the flight equipment, or lack of confidence in his own capability. Students who are low in self-confidence are less likely to pass a checkride and such a failure could further undermine their self-confidence and thus result in a loss of efficiency. Once this downhill process has started the student is unlikely to be able to resist it. [Ref. 13: pp. 37-38]

Table 16 gives the *self-confidence* grading distribution and criteria. According to the grading criteria, the *self-confidence* variable was measured by how confidently a student performed the maneuver and corrected a deviation. Only 27.4 percent of the students performed the maneuver and corrected a deviation with full confidence. However, 24.0 percent of the students performed the maneuver with hesitation and did not show any confidence in handling aircraft. The *self-confidence* variable is expected to have a positive relationship with *flight performance*. It is important to note that overconfidence is sometimes the main reason unsafe maneuvers occur which can result in aircraft accidents.

Table 16. CONFIDENCE GRADING CRITERIA AND DISTRIBUTION

GRADE	FRE-QUENCY	PERCENT	CRITERIA
A	*48*	*27.4*	*A student performs the maneuver without hesitation and has a full self-confidence.*
B	*52*	*29.7*	*A student performs the maneuver with some self-confidence and needs advice for correction.*
C	*33*	*18.9*	*A student performs the maneuver with low self-confidence and needs a lot of advice for correction.*
D	*42*	*24.0*	*A student performs the maneuver with hesitation and does not have any self-confidence.*
TOTAL	*175*	*100*	

(3) Flexibility. *Flexibility* is characterized by a ready capability to adapt to new, different, or changing requirements. *Flexibility*, which in the Korean Air Force pilot's usage is the process by which the pilot compensates for changes of his task, has long been recognized as an important attribute of pilot behavior. A pilot must be able to cope with unexpected change in the control behavior or his flight plan during flight. The need for rapid adaptation by pilots is essential because of capabilities and tactics of modern high performance aircraft. Usually, this *flexibility* can be observed at the stage of intellectual control over the aircraft or at the stage of automatic control stage in flight training.

Table 17 gives the *flexibility* grading distribution and criteria. According to the grading criteria, the *flexibility* variable was measured by how flexible a student was in coping with an abnormal situation. In the author's experience, the Korean ROTC officers had greater *flexibility* in ground and flying situations than the KAFA cadets. Only 18.9 percent of the students performed the procedure appropriately according to the situation. However, 28 percent of students never performed the procedure according to the situation. *Flexibility* is hypothesized to be positively correlated with *flight performance* scores.

Table 17. FLEXIBILITY GRADING CRITERIA AND DISTRIBUTION

GRADE	FRE-QUENCY	PERCENT	CRITERIA
A	*33*	*18.9*	*A student performs the procedure appropriately according to the situation.*
B	*46*	*26.3*	*A student performs the procedure according to the situation but takes some time.*
C	*47*	*26.9*	*A student does not perform the procedure appropriately according to the situation.*
D	*49*	*28.0*	*A student never performed the procedure according to the situation.*
TOTAL	*175*	*100*	

d. Motivation Variable

Table 18 gives the motivation variable's code name and the value coding in the SAS program.

Table 18. MOTIVATION VARIABLE

VARIABLE	CODE	VALUE CODING
Motivation	MOT	Continuous 1 = D (no motivation) 2 = C (low motivation) 3 = B (some motivation) 4 = A (high motivation)

(1) Motivation. One of the fundamental requirements for success in flight training is a positive attitude towards flying. The enthusiasm of students who tend to be romantically-minded seldom results in a proper performance of flying tasks. A great deal of enthusiasm and love of flying is required for success in flight training.

Motivation is indispensible for developing a genuine desire to learn, for mastering the more difficult aspects of the flying task, for resistance to physical and psychological stress during flight. [Ref. 13 : pp. 33-34]

Motivation is evidenced by the progress the student makes during each flight. *Motivation* can be expressed by flying attitudes such as zeal for flying, perseverance, strong will, reaction to stress, positiveness, or desire to achieve. Any student who has high motivation for flight would not allow even a small deviation when he performs the tasks. This *motivation* for flight especially required in instrument flight because instrument flight demands great concentration and perseverance from the pilot. Therefore, it is hypothesized that the correlation between the *motivation* variable and *flight performance* scores would be statistically significant and positive.

Table 19 gives the *motivation* grading distribution and criteria. According to the grading criteria, the *motivation* variable was measured by how positive a student was to correct a deviation in performance. Only 29.1 percent of the students had a strong positiveness to correct even a small deviation. On the lower end of the grade scale, 12.0 percent of the students did not have positiveness to correct even a large deviation.

Table 19. MOTIVATION GRADING CRITERIA AND DISTRIBUTION

GRADE	FRE-QUENCY	PERCENT	CRITERIA
A	*51*	*29.1*	*A student has a strong positiveness to correct even a small deviation.*
B	*49*	*28.0*	*A student has some positiveness to correct a deviation.*
C	*54*	*30.9*	*A student has low positiveness to correct even a large deviation.*
D	*21*	*12.0*	*A student does not have positiveness to correct even a large deviation.*
TOTAL	*175*	*100*	

IV. EMPIRICAL ESTIMATION

A. DATA REVIEW

The theoretical *excellent pilot* model in the previous chapter concluded that pilots should have good flying aptitude, desirable personality traits, sufficient knowledge, and high motivation. The best way to analyze the characteristics of an *excellent pilot* is through the observational data of his activity. However, time, economic, and spatial constraints preclude the gathering of such data in many cases, and necessitate the study of some surrogate activity. Accordingly, it would be preferable to use a score of several psychological tests for analysis and generation of an *excellent pilot* model. However, such psychological tests do not exist in the Korean Air Force. As a surrogate, this study used "record of training."

This "record of training" is one of the student pilot evaluation forms currently used in the Korean Air Force pilot training program. The purpose of this form is to provide information for the Individual Pilot Quality Control (IPQC) and the development of the pilot training program. The form is divided into four basic parts. The first part is concerned with personal data such as:

- Life inventory,
- Military history, and
- Academic history.

The second part is concerned with pilot's flight characteristics such as:

- Flying aptitude,
- Flying skill,
- Flying attitude, and
- Recommended instruction.

The third part is concerned with grades for sub-tasks such as:

- Landing,
- Basic airwork,
- Instrument flight,
- Formation flight, and
- Navigation flight.

The fourth part is concerned with physical fitness such as:

- Sit-ups,
- Push-ups,
- Pull-ups, and
- 2km run.

This form is filled out by the instructor after the student has completed the flight training program. Because an instructor is in the unique position of observing a student's initial reactions to flight, as well as the progress he makes, this single instructor's rating is considered credible.

The rating scale in Table 20 is used to evaluate the student based on each maneuver attempted during overall sorties or observed during the supervised solo mission. Student pilots are rated on a number of traits or flight characteristics. The instructors judges "how much" of each factor the student pilot has. Performance is judged on a 4-point scale. Examples of graphic rating scale is shown in Table 20.

Table 20. RATING SCALE FOR VARIOUS PERFORMANCE DIMENSIONS

GRADE	*CRITERIA*
A	*Constantly exceeds task requirement.*
B	*Frequently exceeds task requirement.*
C	*Frequently below task requirement.*
D	*Constantly below task requirement.*

The data used in this study are the "records of training" of 175 students who completed the Korean Air Force undergraduate pilot training program. There are 141 Korean Air Force Academy cadets and 34 ROTC officers. But the use of these data for this analysis poses some problems because there are no observations of the student pilots who were dropped from the flight training program. The sample may not be representative of the human quality of all the candidate pilots. If students who were differentiated due to flight failure are included, the relation between flight performance and human quality may be more clear. Another problem is the sample size of the ROTC group, which is relatively smaller than the KAFA cadets group.

B. THE REGRESSION ANALYSIS

1. Interpretation of Coefficients

a. *Regression Coefficients*

The coefficient shows the effect the independent variables have on the dependent variable.

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} \ldots \beta_k X_{ki} + \varepsilon_i \tag{4.1}$$

The coefficient β_2 measures the change in Y associated with a unit change in X_2 on the assumption that all other values for the remaining explanatory variables are held constant. Likewise, the coefficient β_3 measures the change in Y associated with a unit change in X_3. In both cases the assumption that the values of the remaining explanatory variables are constant is crucial to our interpretation of the coefficients. [Ref. 14 : p. 77]

b. *Beta Coefficients*

Beta coefficients are occasionally used to make statements about the relative importance of the independent variables in a multiple regression model. To determine beta coefficients, one simply performs a linear regression in which each variable is normalized by subtracting its mean and dividing by its estimated standard deviation. The beta coefficients bear a close relationship to the estimated coefficients of the original unnormalized multiple regression model:

$$\hat{\beta}_j^* = \hat{\beta}_j \frac{S_{X_j}}{S_Y} \qquad j = 2,3,\ldots\ldots,k \tag{4.2}$$

In other words, the beta coefficient adjusts the estimated slope parameter by the ratio of the standard deviation of the independent variable to the standard deviation of the dependent variable. A beta coefficient of .7 can be interpreted to mean that a 1 standard deviation change in the independent variable will lead to a .7 standard deviation change in the dependent variable. [Ref. 14 : p. 90]

c. *Correlation Coefficients*

A statistical procedure useful in determining the relationship between a dependent variable and an independent variable is called the *correlation coefficient.* A correlation coefficient reflects the *degree of linear relationship* between two variables, which we shall refer to as X and Y. The symbol for a correlation is r, and its range is from -1.00 to +1.00. A correlation coefficient tells two things about t[illegible] relationship between two variables: one is the direction of the relationship and the other is the magnitude. The direction of the relationship is either positive or negative. A positive relationship means that as one variable increases in magnitude, so does the other. The magnitude of the correlation is an index of the strength of relationship. Large correlations indicate greater strength than small correlations. The stronger the correlation between two variables (either positive or negative), the more accurately we can predict one variable from the other. [Ref. 1 : pp. 55-61]

2. Hypothesis Test

(1) The T-test. The T-test is used to test whether an estimated slope coefficient is significantly different from a hypothesized value ($\beta = 0$). The level of significance indicates the probability of observing an estimated t-value greater than the critical t-value if the null hypothesis ($\beta = 0$) were correct. Therefore, the result can be explained by saying that a coefficient has been shown to be " statistically significantly positive," or just "statistically significant" at the 10 percent level of significance or 90 percent level of confidence. The Prob$>|t|$ is the probability that a t statistic would obtain a greater absolute value than observed, given that the true parameter is zero. [Ref. 15 : pp. 93-98]

3. The Results of the Multiple Regression Model

Table 21 shows the mean and standard deviation of each variable.

Table 21. THE MEAN AND STANDARD DEVIATION OF EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION
FLY	514.5545	27.2691
APT	2.7542	0.9661
ATT	2.3085	1.1278
MOT	2.7428	1.0098
FLE	2.3600	1.0836
CAL	2.8514	1.0778
CON	2.6057	1.1290
ACA	366.0485	10.1780

The results of the multiple regression model are described in Table 22. The table shows linear coefficients (regression and beta) from the Ordinary Least Squares (OLS) method.

Table 22. RESULTS OF THE REGRESSION MODEL

Variables	Coefficient	Prob > |t|	Beta Coefficient
Intercept	516.887 (56.286)		
APT	13.407 ** (2.803)	0.0001	0.4750
MOT	6.094 ** (2.125)	0.0047	0.2255
ATT	5.195 ** (1.757)	0.0036	0.2148
FLE	-4.612 ** (2.249)	0.0419	-0.1832
CAL	4.528 ** (2.195)	0.0407	0.1789
CON	-3.554 (2.194)	0.1071	-0.1471
ACA	-0.163 (0.155)	0.2929	-0.0611
SOU	-4.106 (3.972)	0.3027	-0.0597

n : 175

R-SQUARE : 0.4934

ADJUSTED R-SQUARE : 0.4690

(   ): Standard Error

** : Significant at 0.05 level

Table 23 shows the correlation coefficient matrix.

Table 23. PEARSON CORRELATION COEFFICIENTS

	FLY	SOU	APT	MOT	CAL	CON	FLE	ACA	ATT
FLY	1.00	-0.11	0.63	0.54	0.50	0.43	0.37	0.03	0.48
SOU		1.00	-0.02	-0.11	0.01	-0.09	0.07	-0.09	-0.12
APT			1.00	0.64	0.72	0.70	0.68	0.15	0.57
MOT				1.00	0.54	0.64	0.50	0.13	0.48
CAL					1.00	0.63	0.66	0.20	0.41
CON						1.00	0.66	0.21	0.55
FLE							1.00	0.25	0.54
ACA								1.00	0.12
ATT									1.00

In the multiple regression model, five of the eight variables were significant at the 0.05 level. They were the *inherent flying aptitude, motivation, calmness, dividing of attention* and *flexibility* variables. All the significant variables had expected signs except the *flexibility* variable. Of the other variables, *self-confidence* and *academic performance* did not have the expected sign. This may be due to specification errors in the variables that are included or excluded from the model, an incorrect mathematical form of the model, or high multicollinearity between two variables.

In fact, there is no universally accepted test of multicollinearity. Instead, most researchers develop a general feeling for the severity and importance of multicollinearity in an equation by looking at a number of the characteristics of the estimated equation. One of the first indications of the possible presence of severe multicollinearity is the combination of a high R-square with low calculated t values for the individual regression coefficients. However, all of the explanatory variables had a greater absolute t value than 1. Therefore, multicollinearity is not expected. [Ref. 14 : pp. 189-191]

a. Aptitude Variables

As expected, two aptitude variables (*inherent flying aptitude* and *dividing of attention*) were significant at the 0.05 level.

(1) Inherent Flying Aptitude. The regression coefficient was significant at the 0.01 level in the model. The correlation coefficient of the *inherent flying aptitude* was 0.63. The 40 percent of *flight performance* variance can be explained by this *inherent flying aptitude* variable. This variable had the highest correlation among the eight predictors. The *inherent flying aptitude* variable was found to be the primary factor among all of the predictor variables in predicting *flight performance*. Thus, a student who has a good *inherent flying aptitude* will have a better *flight performance* than those who have other good characteristics. A student's *inherent flying aptitude* should be evaluated carefully and be applied to predict student success in flight training.

(2) Dividing of Attention. As expected, the regression coefficient was statistically significant at the 0.01 level and had a positive correlation with *flight performance*. The correlation coefficient was 0.48. As discussed earlier, high aircraft speed and complex cockpit instrumentation require rapid information processing by the pilot. Thus, the multiple regression analysis suggests that the *dividing of attention* ability is a fundamental element of a pilot.

b. Biographical Variables

Neither of the two variables (*commission source* and *academic performance*) proved significant in the models.

(1) Academic Performance. The result of the *academic performance* variable did not agree with the hypothesized relationship and was not statistically significant. Therefore, no conclusion could be drawn about the relationship between *flight performance* and *academic performance*.

(2) Commission Source. The *commission source* variable also had a very weak correlation with the dependent variable. The correlation coefficient was -0.11. The difference in individual quality of the two subsets (the ROTC officer group and the KAFA cadet group) in flight performance was insignificant. One possible reason is the small sample size of the ROTC group. As indicated in Table 24, the cadet group demonstrated better performance in most of the quality gradings such as *flight performance*,

dividing of attention, self-confidence, motivation and *academic performance*. A possible reason for this is that the cadet group may be more motivated than the ROTC group. But the ROTC group showed a higher mean grade in *calmness* and *flexibility*. The reason might be because the ROTC group students were already commissioned as officers and therefore had more social experience.

Table 24. MEAN GRADES AND STANDARD DEVIATIONS FOR ROTC AND KAFA STUDENTS

VARIABLE	ROTC		KAFA	
	MEAN	ST/DE	MEAN	ST/DE
FLY	508.14	26.92	516.09	27.21
APT	2.70	0.90	2.76	0.98
ATT	2.03	1.14	2.37	1.12
CON	2.38	1.13	2.66	1.13
CAL	2.88	0.95	2.84	1.11
FLE	2.53	0.99	2.32	2.32
MOT	2.50	0.96	2.80	1.02
ACA	364.05	9.67	366.53	10.27

c. *Personality Variables*

Two of the three personality variables were significant at the 0.05 level. But the result of two variables did not agree with the hypothesized relationship.

(1) *Calmness.* The *calmness* variable was expected to have a positive relationship with *flight performance* and its result conformed with the hypothesized relationship. The regression coefficient was significant at the 0.05 level and the correlation coefficient between *calmness* and *flight performance* was 0.50. This personality trait is essential in handling an unexpected situation or emergency. It is possible that a lack of this *calmness* trait is highly related to aircraft accident due to pilot error. Thus, instructors should observe the *calmness* of students very carefully and apply this observation in pass or fail decision making.

(2) *Self-confidence.* The result of the *self-confidence* variable did not agree with the hypothesized relationship and was not statistically significant. Therefore, no conclusion could be drawn about the relationship between *flight performance* and *self-confidence.*

(3) *Flexibility.* Unexpectedly, the *flexibility* variable was statistically significant and negatively related to *flight performance* scores. The negative sign of the regression coefficient means that the more flexible the student is, the less his *flight performance* score is. As mentioned in the previous chapter, *flexibility* is required at the "intellectual control over the aircraft stage" or at the "automatic control stage" in flight training rather than at the imitation maneuver stage. However, some students' flying ability remained in the "imitation maneuver stage". Therefore, it is suspected that instructor pilots had some difficulty measuring the students' *flexibility* trait in those situations.

d. Motivation Variable

(1) *Motivation.* The regression coefficient of the *motivation* variable was significant at the 0.01 level and had a strong positive relationship with *flight performance.* The correlation coefficient between *motivation* and *flight performance* was 0.54. The *flight performance* score was very sensitive to levels of *motivation.* In conclusion, student pilot's motivation is considered one of the most important factors in predicting student pilot success in flight training.

4. Summary of the Regression Analysis

Table 25 presents a summary of the regression analysis for the multiple regression model. As indicated, 43.6 percent of the criterion variance could be explained by the flying aptitude variables-- *inherent flying aptitude* and *dividing of attention.* The addition of motivation information (*motivation* variable) increased the explained variance by 1.5 percentage points. After entering the *motivation* variable, an additional 3.6 percent criterion variance was explained by personality variables--*flexibility, calmness,* and *self-confidence. Academic performance* explained only 0.2 percent of the flight performance variance. The final equation yields an R-square of 0.4934.

Table 25. SUMMARY OF THE REGRESSION ANALYSIS

VARIABLE ENTERED	Increase in R-square	Multiple R-square
APT	0.4040	0.4040
ATT	0.0321	0.4361
MOT	0.0148	0.4509
FLE	0.0195	0.4703
CAL	0.0094	0.4797
CON	0.0077	0.4874
ACA	0.0022	0.4901

C. THE VALIDITY OF THE MODEL

1. Coefficient of Determination

An estimated regression equation should be capable of explaining the sample observations of the dependent variable Y with some degree of accuracy. That is, the better the fit of the equation, the closer the estimated Y will be to the actual Y. The *coefficient of determination* (R-square) is the ratio of the explained sum of squares to the total sum of squares:

$$R^2 = \frac{ESS}{TSS} = 1 - \frac{RSS}{TSS} \tag{4.3}$$

where

TSS Total Sum of Squares

ESS Explained Sum of Squares

RSS Residual Sum of Squares

The higher the R-square, the closer the estimated regression equation fits the sample data; measures of this type are called "goodness of fit" measures. R-square must lie in the interval

$$0 \leq R^2 \leq 1 \tag{4.4}$$

A value of R-square close to 1 shows a "good" overall fit, whereas a value near 0 shows a failure of the estimated regression equation to explain the values of Y_i better than could be explained by the sample mean $\bar{Y}$. In other words, R-square can be defined as the percentage of the variation of Y around $\overline{Y}$ that is explained by the regression equation. The R-square of the multiple regression model is 0.49. That means 49 percent of the total variance can be explained by the *excellent pilot* model. [Ref. 15 : pp. 28-30]

2. F-test

While the R-square is a measure of the overall degree of fit, a slightly modified version, called the F-ratio, is a "statistical test" of the overall degree of fit of the estimated equation. The F-ratio is defined as:

$$F = \frac{ESS/(K)}{RSS/(n-K-1)} \tag{4.5}$$

It is the ratio of the explained to the unexplained portion of the total sum of the squares, adjusted for the number of independent variables (K) and the number of observations in the sample (n). When the value of F is high, the estimated regression provides an adequate statistical explanation of the deviations of Y_i from $\overline{Y}$. The overall fit of the equation is considered statistically acceptable only if the computed value of the F-ratio is greater than a "critical value" found in the table of F-values.

$$H_0 \quad : \quad \beta_1 = \beta_2 = \beta_k = 0$$

$$H_A \quad : \quad H_0 \textit{ is not true}$$

The computed F-value of the *excellent pilot* model is 20.08. The critical F-value for a 1 percent level of significance is 2.51. A computed F-value greater than 2.51 would reject the null hypothesis and declare that the equation is statistically significant at a 99 percent level of confidence. [Ref. 15 : p. 30]

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The importance of careful pilot selection in the Korean Air Force has become paramount with the "roll out" of the extremely expensive and complex F-16 Fighting Falcon. In addition, constant aircraft accidents due to pilot error emphasize the importance of careful selection even more. While in other countries psychological testing is emphasized in pilot selection, the Korean Air Force has shown less concern about pilot selection research. In the Korean Air Force pilot selection, psychological assessments are made during the initial aptitude checkride. However, these aptitude tests lack standardized criteria. The argument in favor of this type of assessment is that an instructor can distinguish a student's ability by virtue of his own experience. In essence, the Korean Air Force needs a reliable selection device to improve predictor validity.

This study has specified an *excellent pilot* model for the Korean Air Force pilot selection program. Several human qualities have been analyzed and their relationships with flight performance have been identified. For this analysis, "record of training" of the undergraduate pilot training was used. The total flight performance score was selected as a dependent variable and eight human qualities were selected as independent variables based on previous findings. The resulting *excellent pilot* model answered the the research questions posed earlier and recommended a method to improve the validity of predictors for the Korean Air Force pilot selection. This *excellent pilot* model answered the questions:

- What are the primary factors that predict aviation excellence ? and
- How do these factors apply to student pilot screening in the Korean Air Force ?

The beta coefficients reflect the relative importance of the predictors. As was shown by the results of the regression model (Table 22), the *inherent flying aptitude* variable is the most important factor in predicting student pilot success in flight training. Next, a strong *motivation* variable predicts good flight performance in flight training. Additional human qualities such as *dividing of attention* and *calmness* are expected to improve flight performance.

The following formula provides the expected flight performance for a specific student:

Flight performance = 516.887 + 13.407*(APT) + 6.094*(MOT) + 5.195*(ATT) - 4.612*(FLE) + 4.528*(CAL) - 3.554*(CON) - 0.164 *(ACA) - 4.107*(SOU)

The computed flight performance value will be obtained by appropriately weighting a student pilot's qualities such as flying apititude, motivation, personality, commission source, and academic performance grade.

Consider the following example of an instructor actually using the formula. After a certain amount of flying, an instructor rates his student's quality like this: the *inherent flying aptitude* is good (B = 3), *motivation* is good (B = 3), *dividing of attention* is good (B = 3), *flexibility* is fair (C = 2), *calmness* is fair (B = 2), *self-confidence* is excellent (A = 4), academic performance is 365.1 and he is a KAFA cadet (commission source = 0). This student's flight performance score should be 516.8. This score predicts that he will successfully complete the flight training program because his expected score is above the mean *flight performance* score. This computed value, obtained by applying this model, will enhance the predictive validities in student pilot screening.

The anticipated benefit of this study is the improvement in the screening of undergraduate pilots in the Korean Air Force. The *excellent pilot* model, using data from undergraduate pilot training programs, should lead to an increasing validity of the screening predictors. Also, predictors that are defined in the model could be used to improve the pilot training program and Individual Pilot Quality Control (IPQC). Improvements in the quality of Korean Air Force pilots will result in a decreasing accident rate and an increase in air combat readiness.

B. RECOMMENDATIONS

Because of the small sample size (175 students), the findings of this study are not enough to generate a specific selection policy. Therefore, it is recommended that a sufficient data sample be collected from the Air Force Academy and undergraduate pilot training programs. Adequate overlap in time intervals should be allowed to provide for maximum record matching. Accurate and confidential instructor ratings should be stressed for future study. If these weaknesses can be corrected, future research may be able to improve or refine the detailing policy and create a more effective method of predicting student pilot success in the training program.

The author strongly recommends that the Korean Air Force organize a pilot selection research and development (R&D) team, equipped with necessary selecting devices, a computer center for research, statistical packages, and personnel with the skills necessary to perform that work. Cooperation with the U.S Navy Recruitment Command selectors, Naval Aerospace Medical Institute's (NAMI) flight examiners, and NAMI psychologists in getting information may be beneficial. Finally, the purpose of this study was essentially to provide insight into the importance of aviation psychology in student pilot screening and selection. It is hoped that these results will stimulate the Korean Air Force to have more concern about its pilot selection process.

APPENDIX. SAS PROGRAM

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TITLE1 'THESIS';
DATA QUALITY;
INPUT STATE ID 1-3 FLY 5-10 APT 12 CAL 14
CON 16 MOT 18 FLE 20 ACA 22-26
ATT 28 SOU 30;
CARDS;
PROC REG DATA=QUALITY;
MODEL FLY= APT ATT ACA SOU CAL  CON FLE MOT/  STB;
PROC FREQ;
TABLES CAL CON MOT SOU ATT FLE APT;
PROC MEANS;
VARIABLES FLY ACA;
PROC CORR;
VAR FLY SOU  APT MOT CAL CON FLE ACA ATT;
PROC STEPWISE;
MODEL FLY= APT ATT FLE CAL CON SOU ACA MOT/SLE =.9;
PROC REG DATA=QUALITY;
MODEL FLY= APT ATT SOU ACA CAL FLE CON MOT/P ;
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